

Preliminary VDL Mode 2 Bench and Flight Test Results

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Presentation Overview

- VDL Integrated Performance Evaluation Rack
 - VIPER Ground & Airborne Equipment Description
- Pre-flight Bench Testing
 - Spectral characteristics and Receiver (Rx) sensitivity
 - Block Diagram & Sample Test Message
- Flight Testing
 - Goals
 - King Air Antenna Performance
 - Flight Test Results

VIPER Equipment Description

- VDL Mode 2 (VDLM2) Equipment
 - Park Air Radio (PAR) 5525D8 Multimode Transceivers
 - Currently operate in transmit (Tx) or receive (Rx) mode only
 - Advanced Relay Corporation HDLC Cards
- Host Computers
 - CyberResearch MPC-6020 with 10.4” LCD Display
 - Software configures Tx or Rx option
 - Spectrum analyzer & Ohio U. program measures power
- GPS Receivers
 - Novatel 3151 (12 Channels)

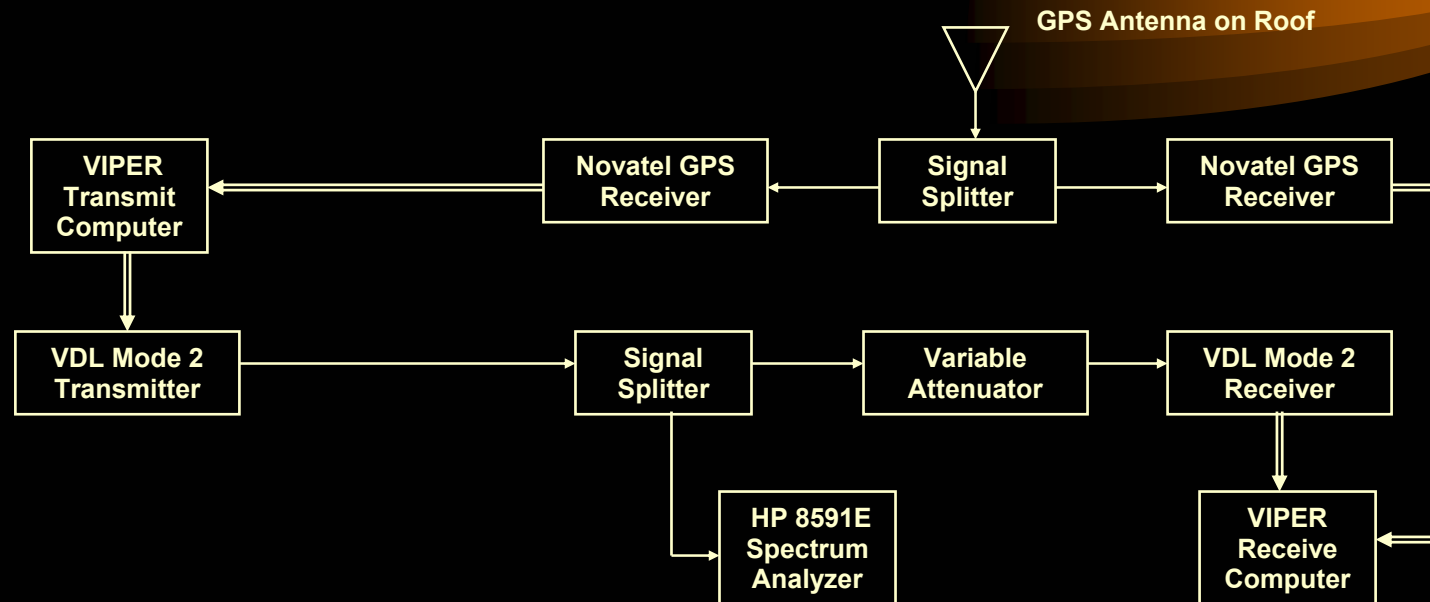
VIPER Ground and Airborne Components



- Top
 - Novatel GPS Receiver
- Middle
 - Park Air VDL Mode 2 Transceiver
- Bottom
 - CyberResearch Computer

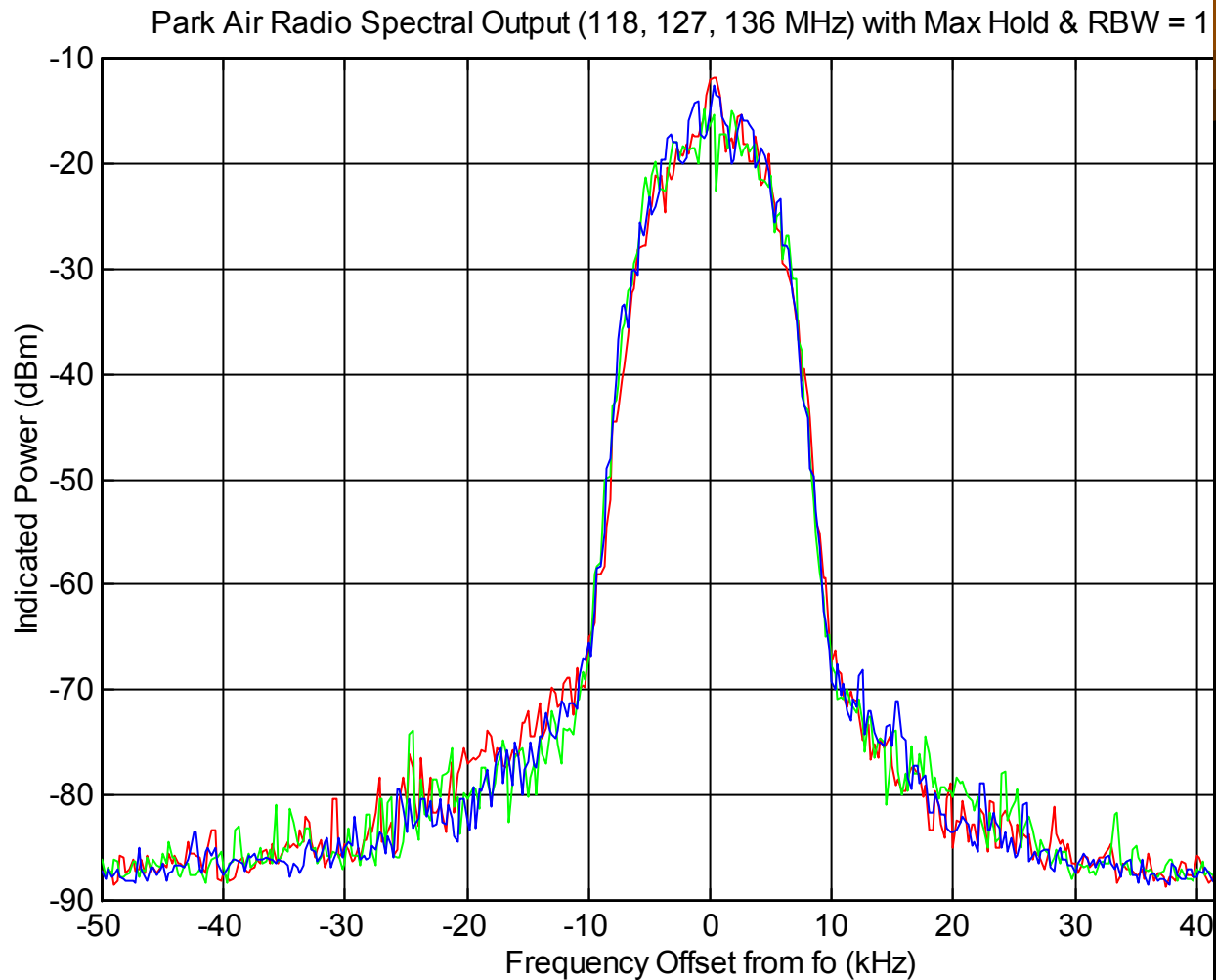
VDL Mode 2

Bench Test Configuration



- Bench test simulates flight test environment
- VIPER Tx Computer Generates Test Messages
 - Simulated “weather-related” data (Actual weather info to be used later)
 - Message length and duty cycle limits require further investigation

Measured Spectral Characteristics



Tx Characteristics

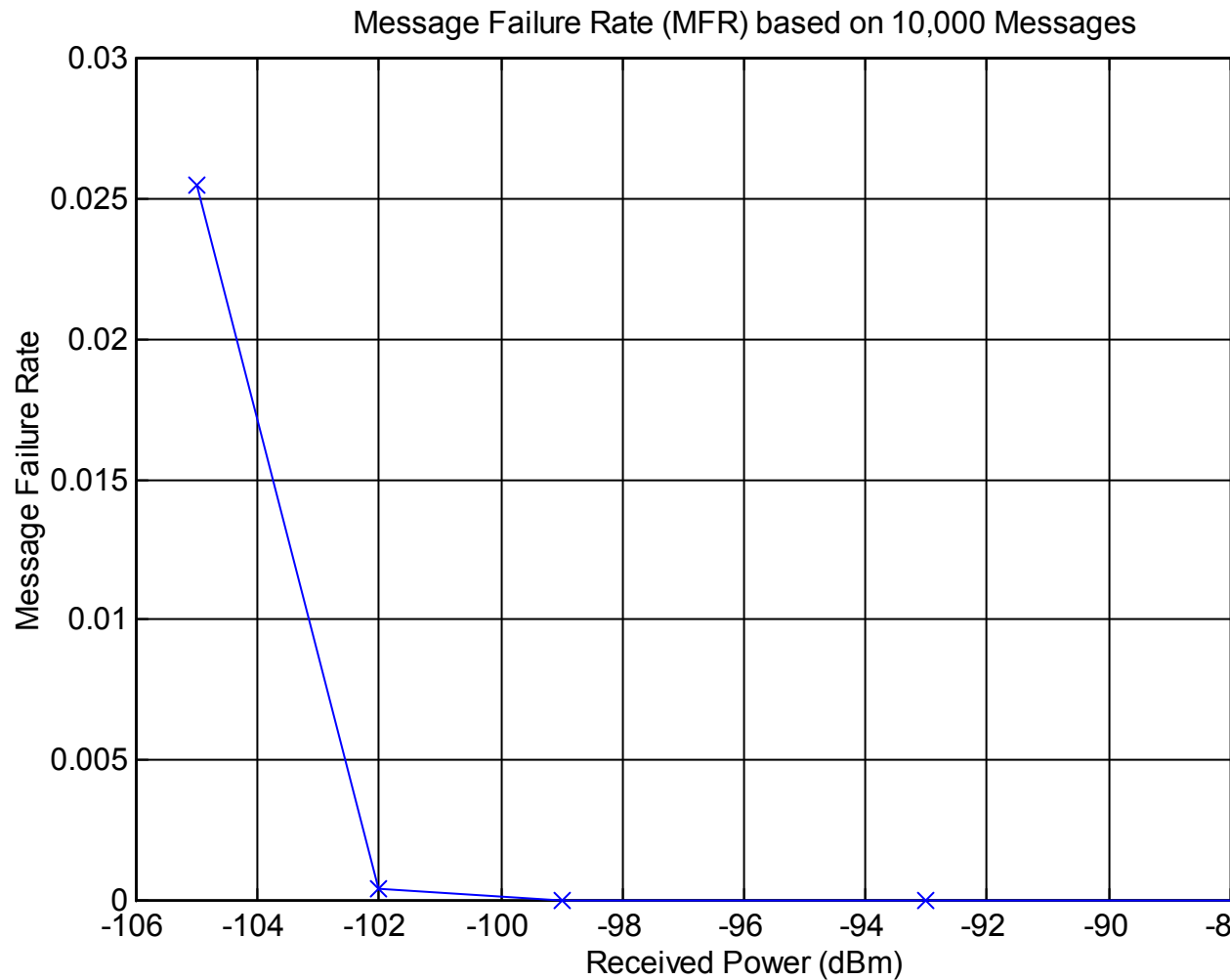


- Tx computer generates test messages
 - 223 bytes in length
 - Message counter for determining message count
 - GPS location of Tx station
 - Random fill bits
 - 32-bit checksum
 - Weather-related messages will be used eventually
- Messages rate = approx. $3/2$ seconds = 1.5 Hz
- Power measured with HP8591E Spec Analyzer
 - Resolution Bandwidth (RBW) = 1 kHz for trace
 - RBW = 30 kHz for sensitivity measurements

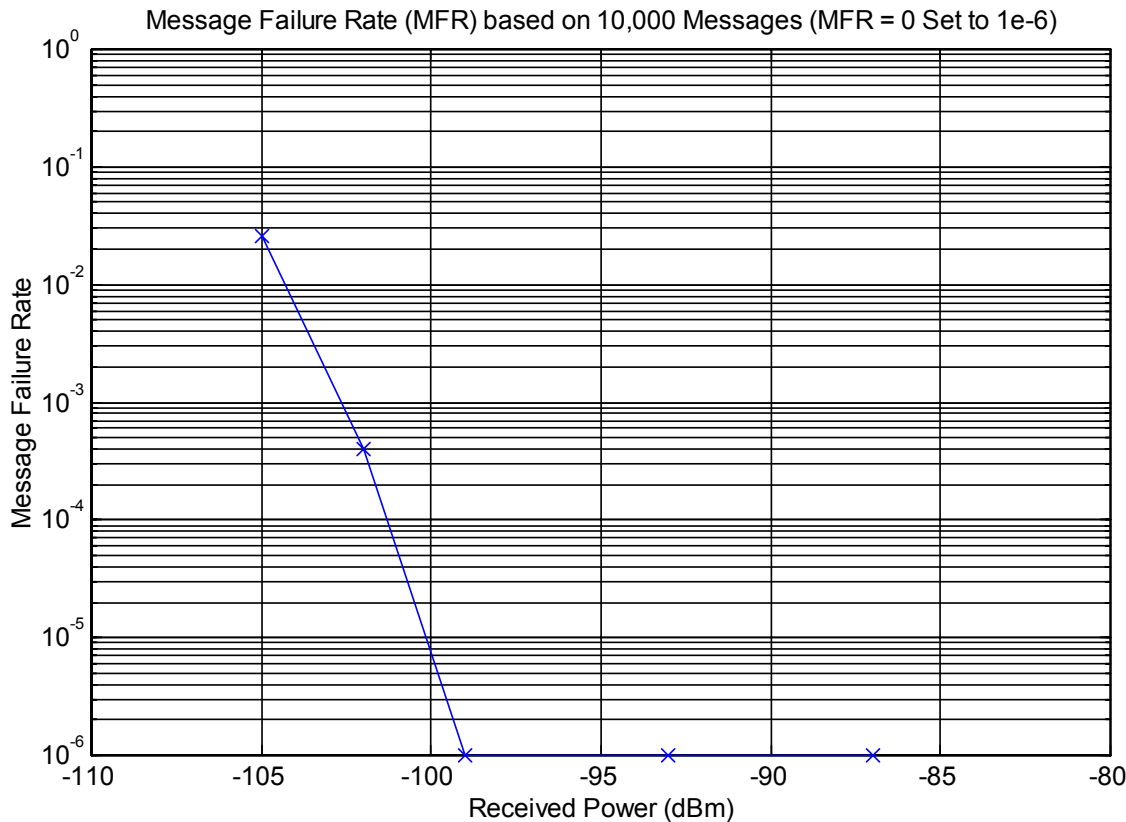
Rx Mode Characteristics

- PAR VDLM2 equipment does not output “bad” messages
 - Raw Bit Error Rate (BER) not readily available
 - Use Message Failure Rate (MFR)
 - Determine sensitivity by post-processing data
- Reported MFR based on 10,000 messages
 - Test time per data point was approximately 2 hours
- Screen displays GPS time, range, message count, and count difference

Measured Sensitivity (view 1)



Measured Sensitivity (view 2)



- Set MFR= $1e-6$ for plotting purposes
- Interpolated Sensitivity Points

<u>Power</u> <u>(dBm)</u>	<u>Approx.</u> <u>MFR</u>
-101	1e-5
-102	5e-4
-103	1e-3
-104	1e-2

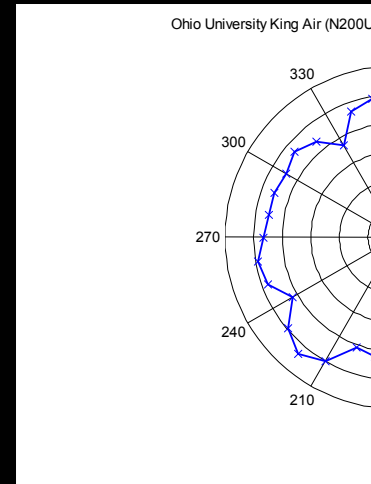
Measured sensitivity compares well with -103 dBm claimed by manufacturer.

Flight Test Preparation

King Air C-90 (N200U) Aircraft

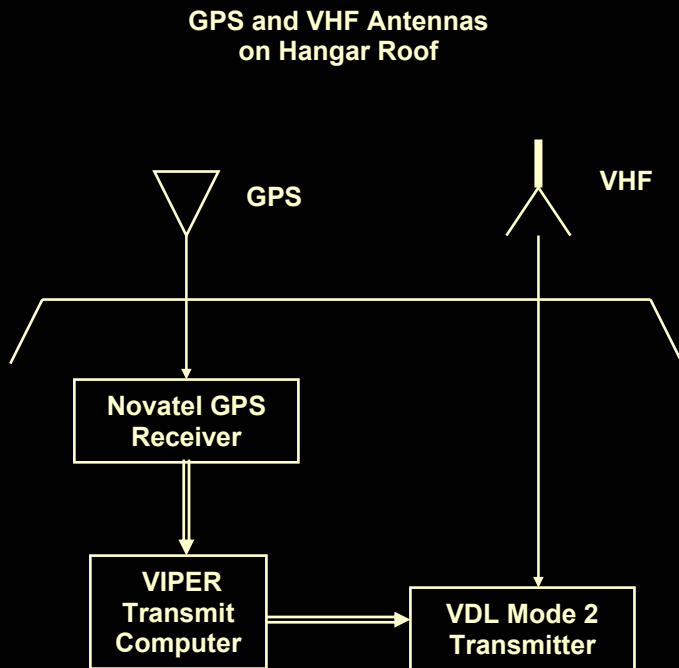


- Vertically Polarized (VPOL) Rx antenna on top of aircraft fuselage

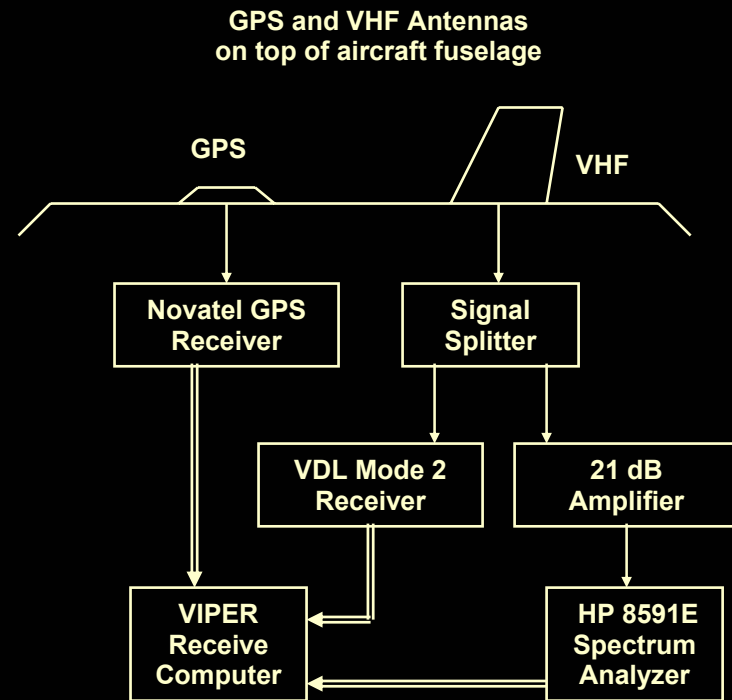


Flight Test Configuration

VDLM2 Ground Station

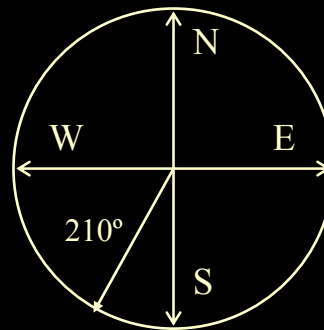
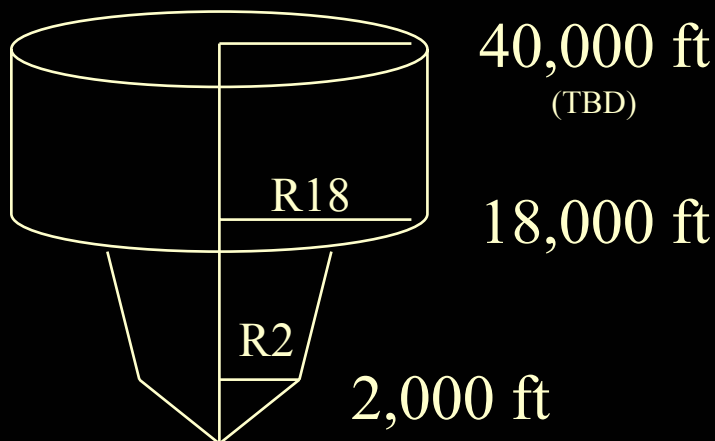


VDLM2 Airborne System



Flight Test Profile

- Tested the 210° compass radial to the extent of coverage at two altitudes above ground level:
 - 2,000 ft. AGL (typical minimum vectoring altitude)
 - Timely weather should not be needed below this altitude
 - 18,000 ft. AGL (bottom of current ARINC coverage)



Compass Radials

210° radial chosen from Ohio University Airport (UNI) to minimize traffic-based course deviations

Current Method for Measuring In-Flight Received Power

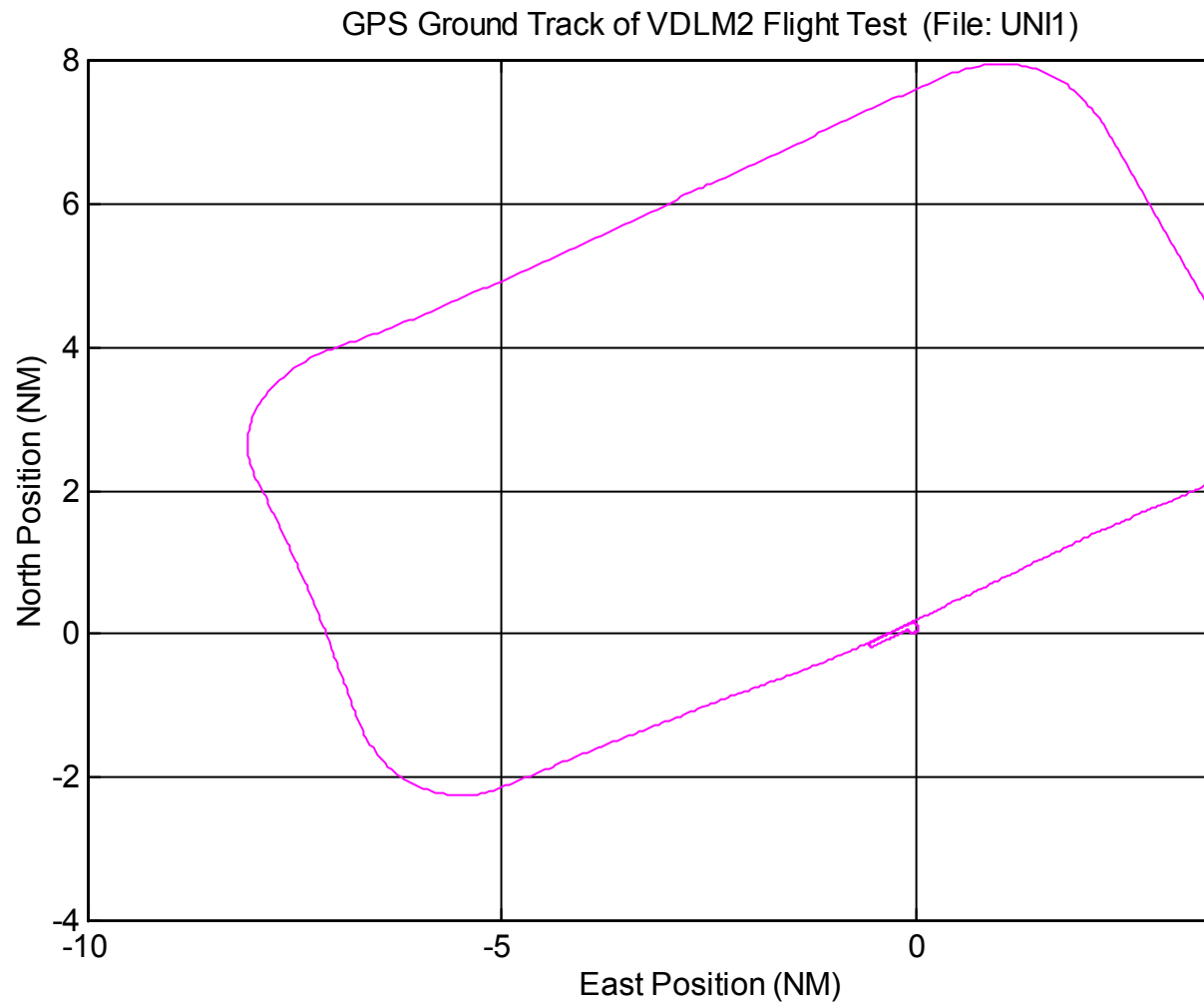
- Use HP8591E Spectrum Analyzer (SA)
 - Power Measurement Settings
 - Resolution Bandwidth = Video BW = 30 kHz
 - Center measurement on known Tx frequency
 - Max Hold for 3 seconds
 - Allows for non-synchronized operation (SA & VDLM2)
 - Peak Search and record value at center frequency
- Customized Ohio U. data logging software
 - Multitasks with VIPER software under Windows 2000
 - Time tags power measurement with GPS time for post processing

A Collection of Interesting Pictures



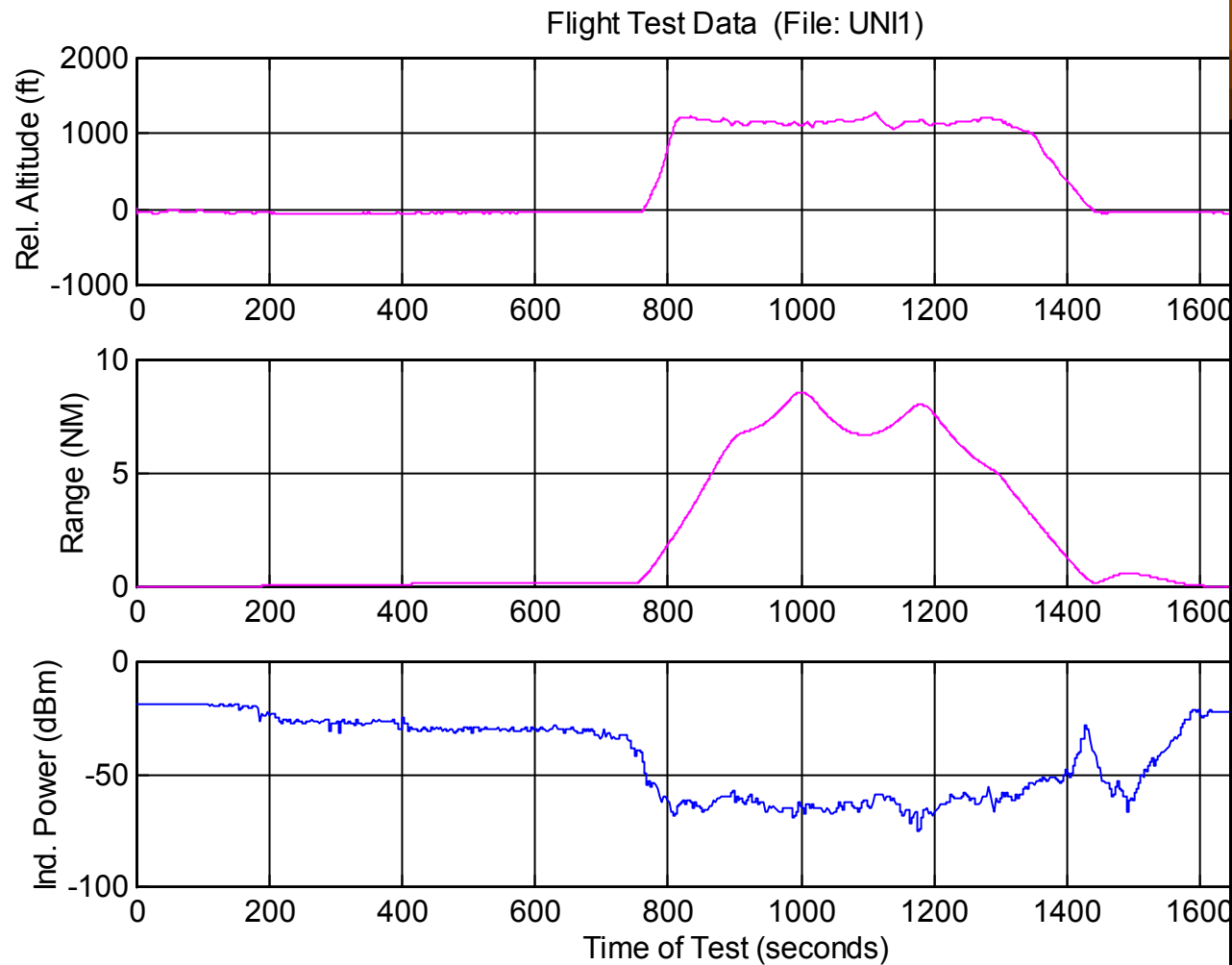
Data File 1

Shakedown Flight



Data File 1

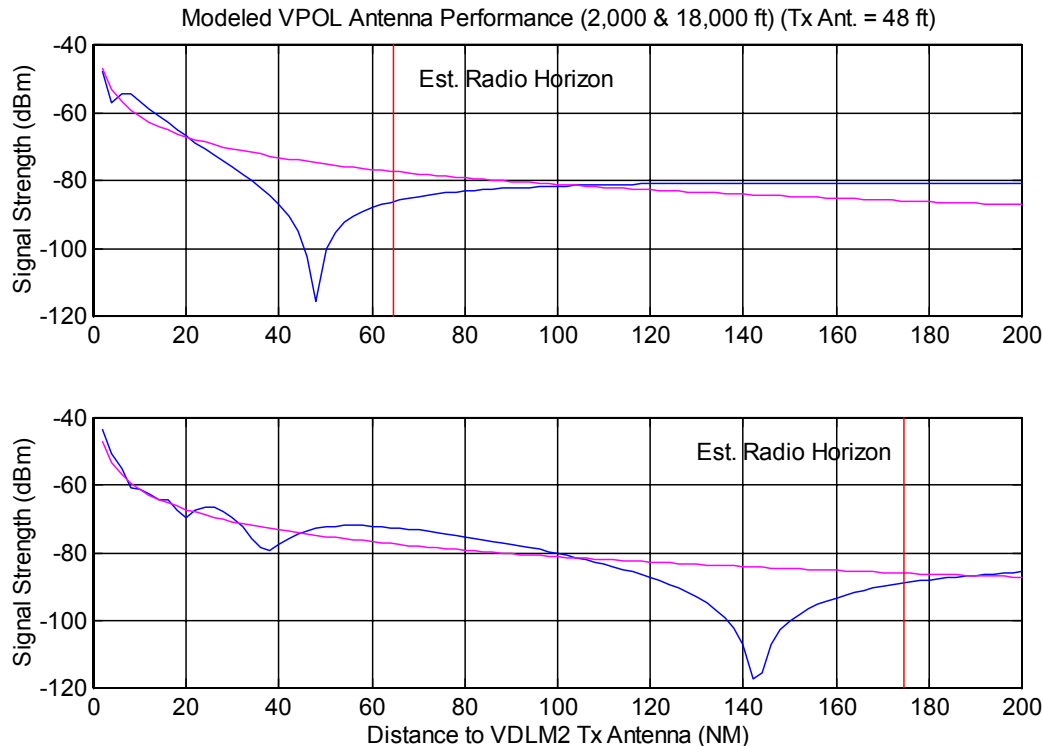
Shakedown Flight (2)



Predicting Performance at 2,000 ft and 18,000 ft (AGL)

- Model written by Ohio University
- Models terrain as uniform spherical earth
- Can vary surface conditions
 - Salt water
 - Fresh water
 - Average earth (used in this analysis)
 - Swamp
 - Desert
- Assume isotropic VPOL Tx antenna
- Coverage performance varies from free space due to multipath and path length difference

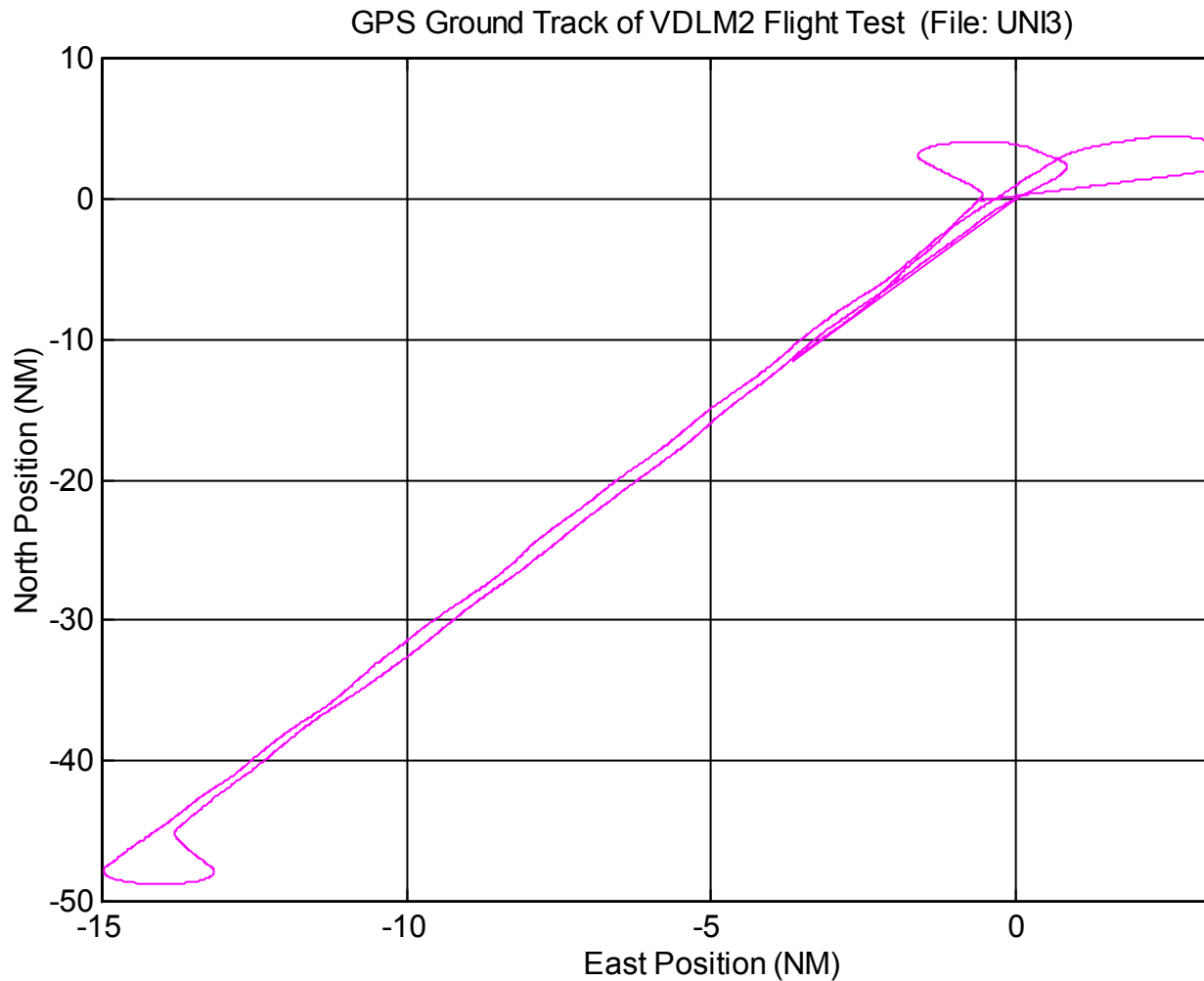
Predicting Performance (2)



- Rx at 2,000 ft
 - Signal expected to be lost at ~45 NM
- Rx at 18,000 ft
 - Signal expected to be lost at ~140 NM
- Signal increase beyond loss region is artificial (need model update)
- Radio horizon using 4/3 earth radius propagation estimates

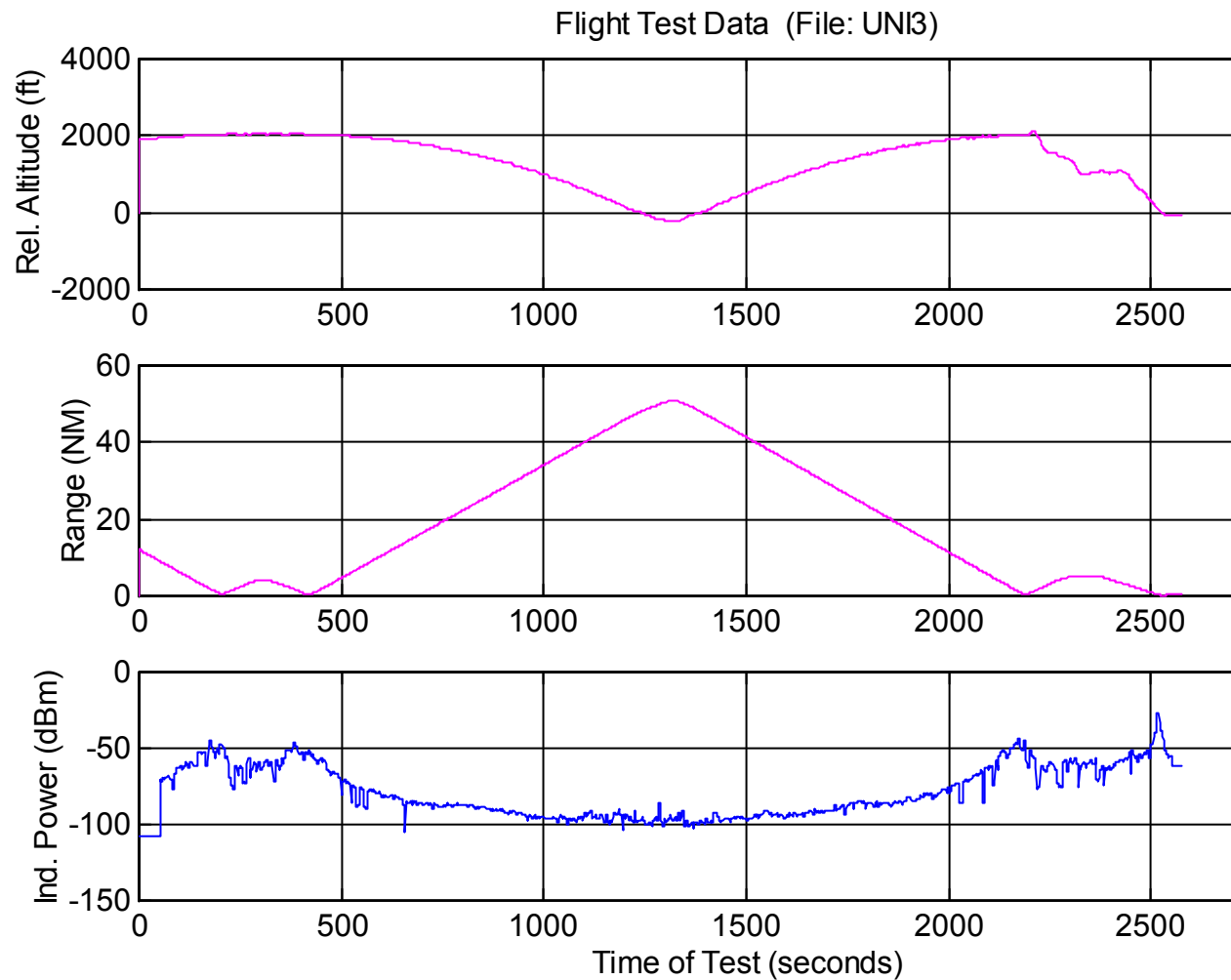
Data File 2

Radial at 2000 ft AGL



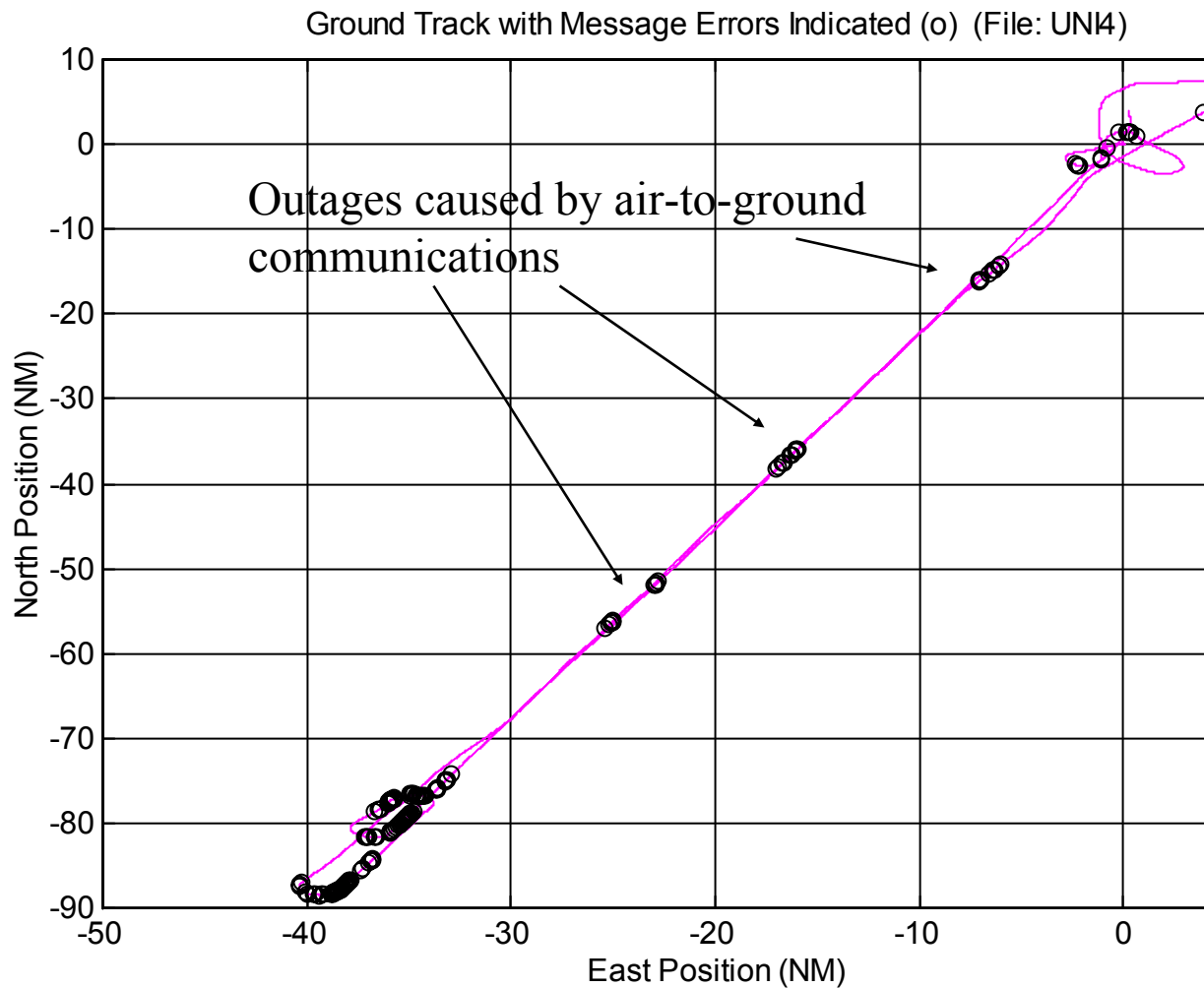
Data File 2

Radial at 2000 ft AGL (2)



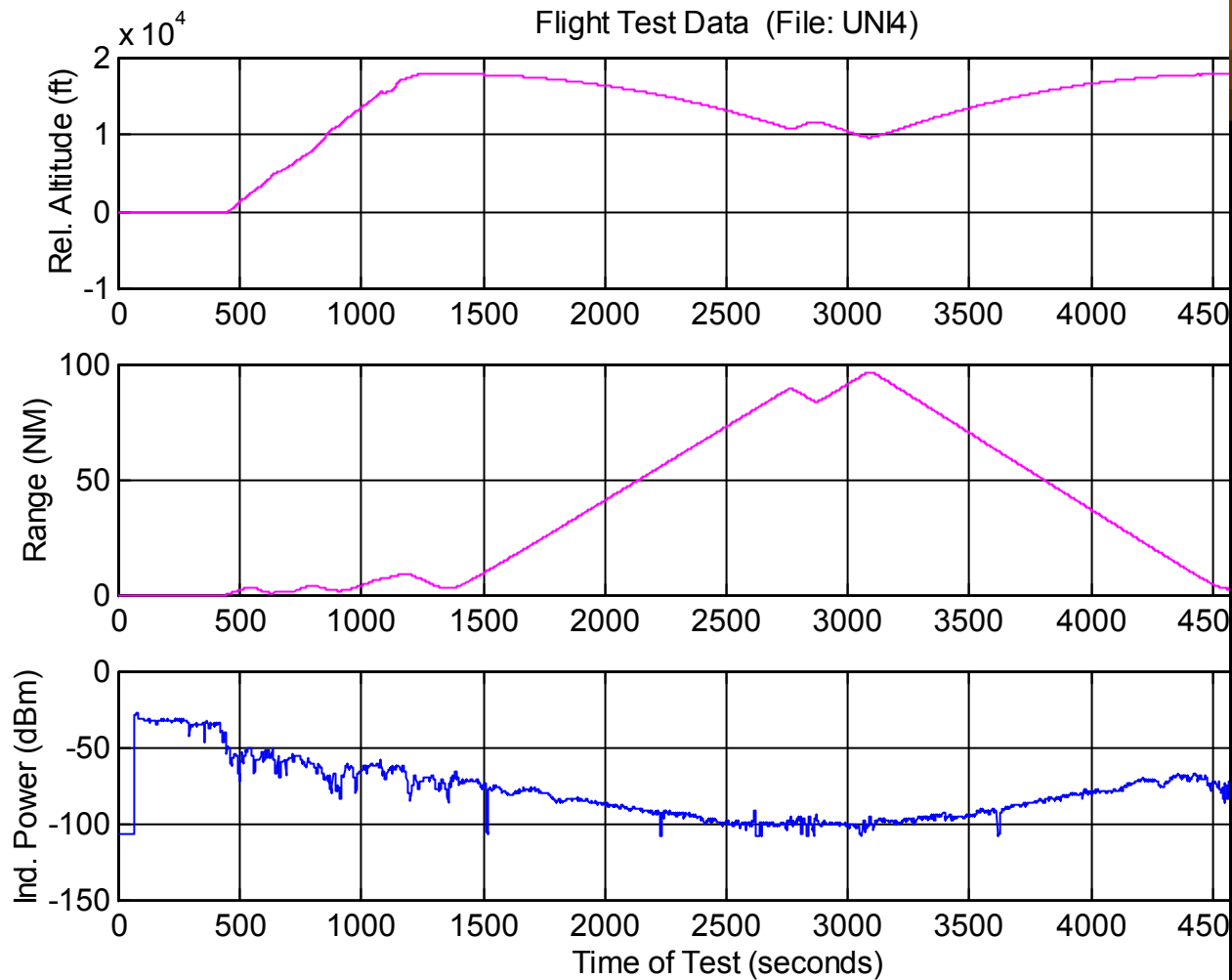
Data File 3

Radial at 18,000 ft AGL

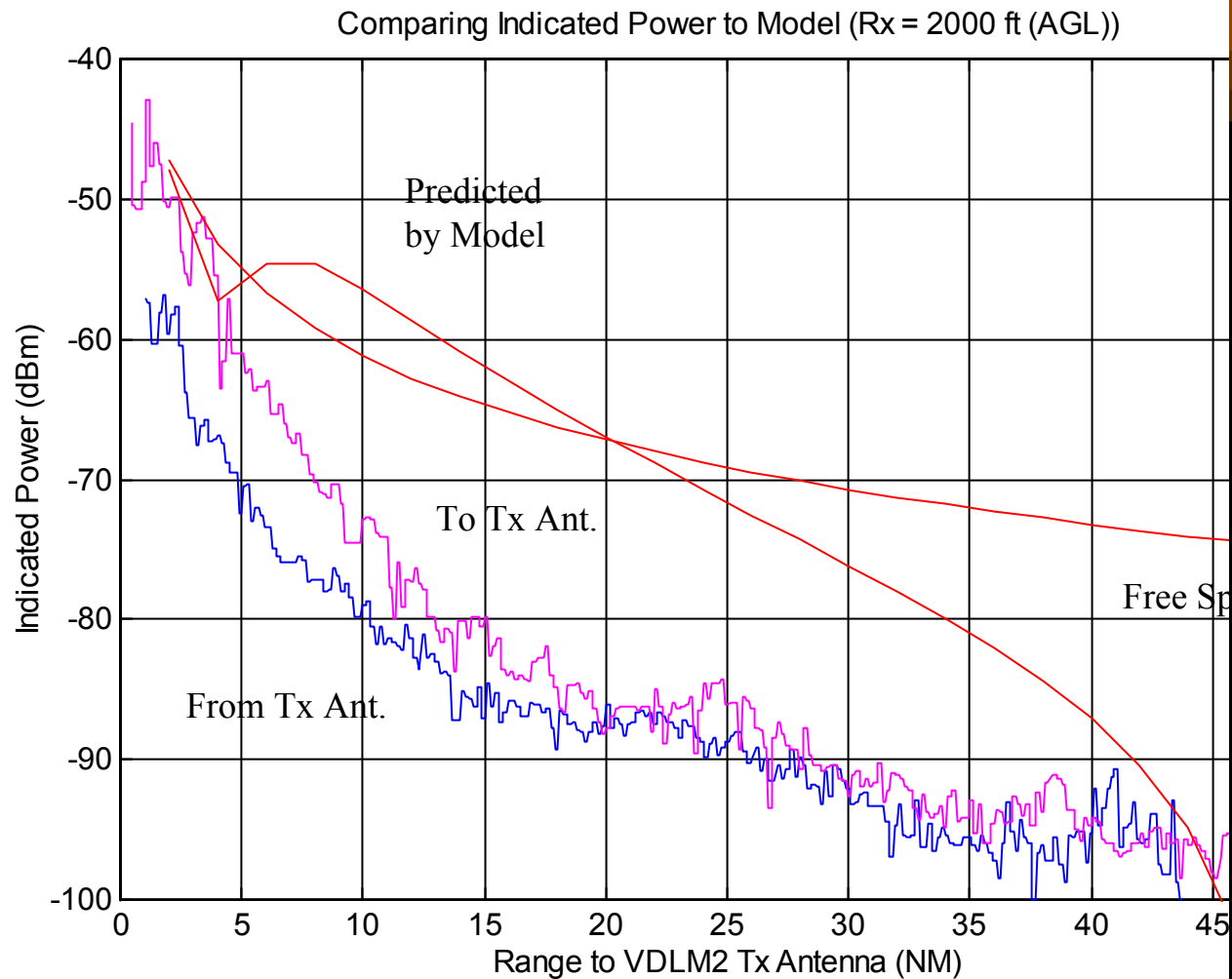


Data File 3

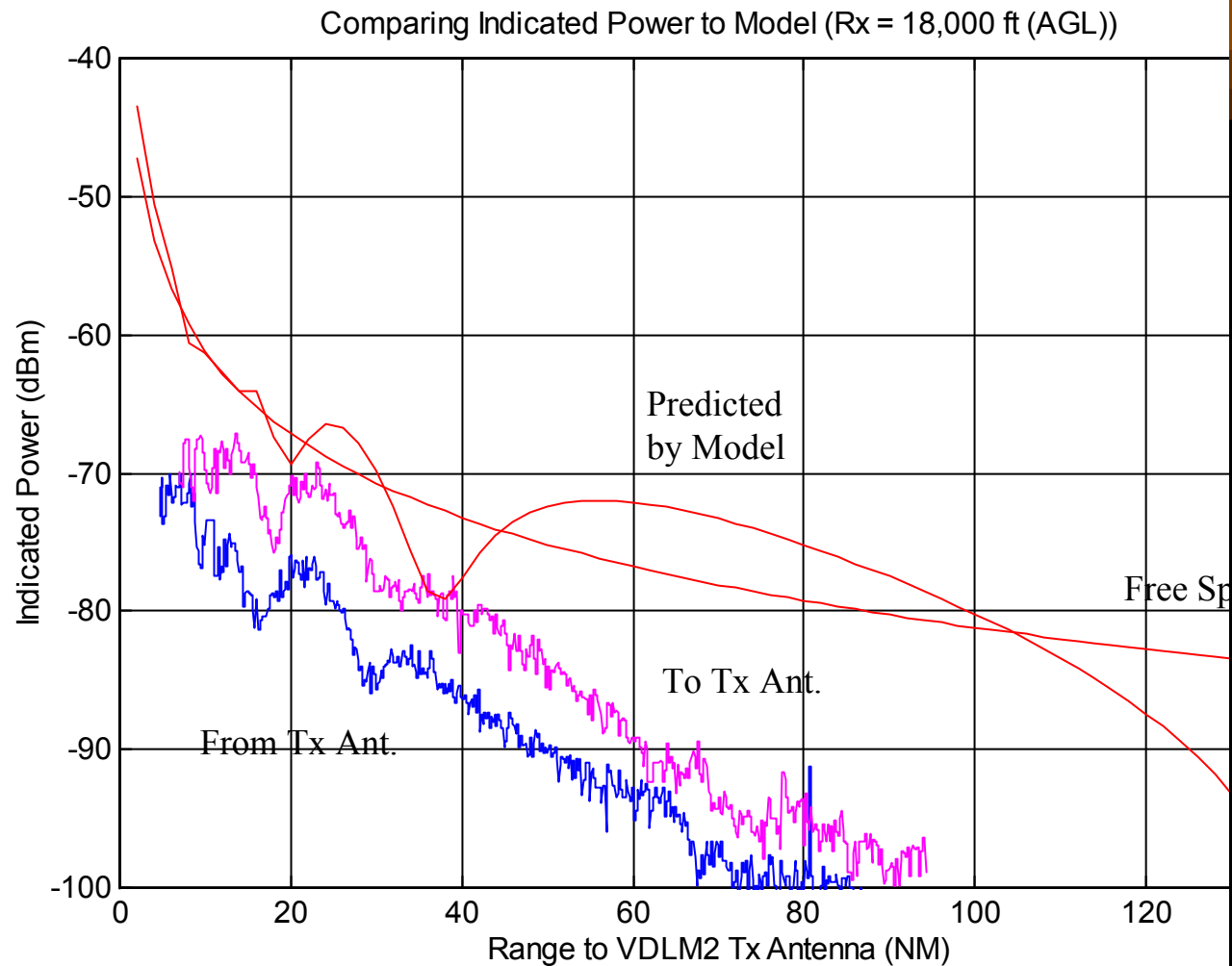
Radial at 18,000 ft AGL (2)



Comparing Received Signal Strength to Predicted (2,000 ft)



Comparing Received Signal Strength to Predicted (18,000 ft)



Comments on Received Data versus Model Prediction

- Flight test data and model are not in very good agreement (yet) - still under investigation
 - Flight data is biased from model (6 - 16 dB)
 - Model predicts location of fades at 18,000 ft AGL
- Potential sources of model mismatch
 - Rx and Tx antenna calibration error
 - Tx antenna on hangar edge
 - Non-uniformity of local terrain